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BASIC Application Programs—Mathematics I

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Other publications in the continuing series of curriculum material published by DEC for use with EduSystems 10 through 80 are listed below. Please inquire directly for prices on classroom quantities.

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BASIC APPLICATION PROGRAMS

The programs contained in this series are designed to demonstrate how the computer can be applied in a meaningful way to problems of many disciplines. The problems and the corresponding programs are, for the most part, quite simple and are designed to be "jumping off points" for students from the high school level on up.

All of the programs, with very few exceptions, may be run on EduSystems 10 through 80, PDP-8 Family and PDP-11 Family computers. Exceptions are noted in the program descriptions.

DEC welcomes contributions of programs and write-ups for use in this series. Contributors will be credited as program "Source". Please send programs and descriptions to Educational Marketing (5-2).

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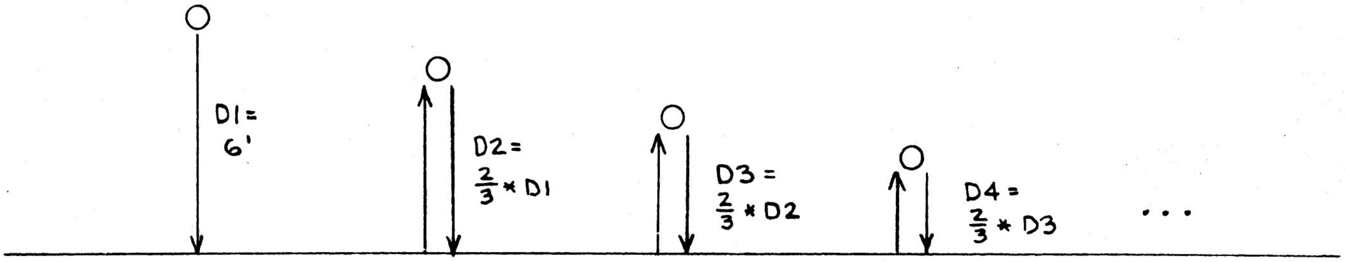
Graphing	DIAMON	Plots an N by N diamond matrix.
	PLOTFN	Plots any function.

AREA: Mathematics NUMBER: 8-1 NAME: BASKT
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: This program illustrates how the computer can be used to solve a problem using exponential convergence. The problem is:

Holding a ball six feet from the floor and letting it drop, a basketball player noticed that the ball bounced back up only two-thirds of that height (four feet). On the second bounce, the ball rose to only two thirds of the second height (two feet, eight inches). The third bounce brought it to two-thirds of the previous height, and so on. What was the total distance the ball traveled--both up and down--before it came to rest?

USAGE: A diagram can be used to show how far the ball bounces each time.



We notice that after the 1st bounce, the ball has traveled (at floor level):

$$D1 + 2 * D2 \quad \text{or} \quad D1 + 2* (2/3 * D1)$$

and that after 2 bounces, the ball has traveled:

$$D1 + 2*D2 + 2*D3 = D1 + 2*(2/3*D1) + 2*(2/3 * 2/3 * D1)$$

Hence, with each additional bounce, the ball travels an additional distance of:

$$2*D1*(2/3)^n \quad \text{or} \quad 12*(2/3)^n$$

Now it is a simple matter to write a program which increments the total distance traveled and print out the results after each bounce.

```
1 PRINT "PROGRAM BASKT"
2 PRINT
3 PRINT "BOUNCES","DISTANCE"
4 PRINT
5 LET D=6
10 FOR X=1 TO 50
20 LET D=D+12*(2/3)↑X
30 PRINT X,D
40 NEXT X
99 END

RUN

PROGRAM BASKT

BOUNCES        DISTANCE

 1              14
 2              19.33333
 3              22.88889
 4              25.25926
 5              26.83951
 6              27.893
 7              28.59534
 8              29.06356
 9              29.3757
 10             29.5838
 11             29.72253
 12             29.81502
 13             29.87668

 32             29.99994
 33             29.99996
 34             29.99997
 35             29.99998
 36             29.99998
 37             29.99999
 38             29.99999
 39             29.99999
 40             29.99999
 41             29.99999
 42             29.99999
 43             29.99999
 44             29.99999
 45             29.99999
 46             29.99999
 47             29.99999
 48             29.99999
 49             29.99999
 50             29.99999

READY
```

EDUCATIONAL BENEFIT: The student can see, by means of a contemporary example, how a progression can be used to solve a problem. He also learns to solve a problem which would be quite difficult to do by hand, especially after the first few terms.

AREA: Mathematics NUMBER: 8-2 NAME: Bicycl
SOURCE: Digital Equipment Corp LANGUAGE: BASIC
DESCRIPTION: The solution to this problem illustrates how the computer can be used as a powerful calculator. The problem is:

A boy on a bicycle and a man in a car start at the same time from town A for town B, 110 miles away. They travel over the same road at 6 and 40 miles per hour respectively. When the man in the car reaches B, he will stop for 15 minutes and then start back again. How many hours will the boy on the bicycle have traveled when he meets the car on its return trip?

USAGE: Let's set up our equations first. Remember distance = rate * time or T = D/R. Letting T1 be the time the car has traveled before it starts the return trip, then:

$$T1 = \frac{110 \text{ mi}}{40 \text{ mph}} + \frac{1}{4} \text{ hr.}$$

The bicycle has traveled T1 * 6 mph at the time the car starts back. Hence the time until they meet is

$$T2 = \frac{110 - T1*6}{40 \text{ mph} + 6 \text{ mph}}$$

The total time is T1 + T2, so now we can easily write a program to solve the problem:

```
 5 PRINT "PROGRAM BICYCL"
 6 PRINT
10 LET T1=110/40+1/4
20 LET T2=(110-6*T1)/(40+6)
30 PRINT "CYCLIST HAS TRAVELED";T1+T2;"HOURS WHEN BOTH MEET."
99 END

RUN

PROGRAM BICYCL

CYCLIST HAS TRAVELED 5 HOURS WHEN BOTH MEET.
```

Not very difficult and the numbers "come out even." But they don't have to. Let's try it over a distance of 112 miles with speeds of 7.5 mph and 46 mph respectively. The computer solves this one just as easily. Can you?

```
READY

10 LET T1=112/46+1/4
20 LET T2=(112-7.5*T1)/(46+7.5)

RUN

PROGRAM BICYCL

CYCLIST HAS TRAVELED 4.401869 HOURS WHEN BOTH MEET.


READY
```

EDUCATIONAL BENEFITS: Computers can be used as powerful calculators too.

AREA: General NUMBER: NAME: CAI-ADD
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program demonstrates a simplified Computer Assisted Instruction drill and practice routine. The user determines how many digits each problem will contain. Then, ten addition problems are produced with the user providing the answer after each problem is presented. After the last problem is correctly answered, the score is printed with an appropriate comment.

```
  5 REM - CAI ADDITION, 10 PROBLEMS
 10 PRINT "HOW MANY DIGITS";
 20 INPUT N
 22 LET W=0
 25 FOR X=1 TO 10
 27 LET Q=0
 30 LET A=INT(10↑N*RND(0))
 40 LET B=INT(10↑N*RND(0))
 50 PRINT
 60 PRINT "   ";A
 70 PRINT "  +";B
 80 PRINT "  -----"
 90 PRINT "   ";
100 INPUT G
110 IF G=A+B THEN 140
115 GOSUB 200
120 PRINT "WHAT?? TRY AGAIN"
130 GO TO 50
140 PRINT "THAT'S RIGHT. TRY ANOTHER"
150 NEXT X
155 PRINT
160 PRINT "YOU GOT"10-W"CORRECT THE FIRST TIME"
165 IF W<=3 THEN 180
170 PRINT "BUT YOU MISSED"W
175 STOP
180 PRINT "GOOD WORK!"
185 STOP
200 LET Q=Q+1
205 IF Q>1 THEN 120
210 LET W=W+1
215 RETURN
999 END
```

```
RUN

HOW MANY DIGITS? 2

   24
 + 29
-----
 ? 52
WHAT?? TRY AGAIN

   24
 + 29
-----
 ? 53
THAT'S RIGHT. TRY ANOTHER

   72
 + 31
-----
 ? 103
THAT'S RIGHT. TRY ANOTHER

   30
 + 4
-----
 ? 34
THAT'S RIGHT. TRY ANOTHER

   48
 + 49
-----
 ? 87
WHAT?? TRY AGAIN

   48
 + 49
-----
 ? 97
THAT'S RIGHT. TRY ANOTHER

   50
 + 4
-----
 ? 54
THAT'S RIGHT. TRY ANOTHER
```

```
   23
 + 30
-----
 ? 53
THAT'S RIGHT. TRY ANOTHER

   19
 + 91
-----
 ? 100
WHAT?? TRY AGAIN

   19
 + 91
-----
 ? 110
THAT'S RIGHT. TRY ANOTHER

   24
 + 98
-----
 ? 112
WHAT?? TRY AGAIN

   24
 + 98
-----
 ? 122
THAT'S RIGHT. TRY ANOTHER

   25
 + 3
-----
 ? 28
THAT'S RIGHT. TRY ANOTHER

   87
 + 92
-----
 ? 179
THAT'S RIGHT. TRY ANOTHER

YOU GOT 6 CORRECT THE FIRST TIME
BUT YOU MISSED 4
```

EDUCATIONAL BENEFIT: This program could be used for drill and practice in a math class. However, it was designed to merely demonstrate the basic idea behind a traditional Computer Assisted Instruction program. It may be used to give students some clues for writing more sophisticated CAI programs.

AREA:	Mathematics	NAME:	CAI-AD2
SOURCE:	David H. Ahl, DEC	LANGUAGE:	BASIC

Descritpion: This program is a somewhat more advanced version of CAI-ADD.

In particular, the extensions include questions on how many problems you wish to do and how many digits you wish to work with. The computer suggests working with 4 or fewer digits if the user specifies 5 or more (this limit can be changed in Statement 14).

Also, the columns of numbers are right justified in Statement 60 and 70. This is a useful technique for formatting any kind of output. The generalized form of the statement is:

```
PRINT TAB(W-INT (LOG(N)/ LOG(10)+1));N
```

"W" represents the width of the field while N is the number. You save a little computing time by using the numeric value of LOG(10), i.e., 2.302585 rather than computing the log every time.

Statements 141 to 153 replace the single Statement 140 in CAI-ADD. These statements simply print out one of four alternative messages of reinforcement when the correct answer is given.

```
READY

TAPE

   5 PRI "ADDITION PRACTICE"
   6 PRI
   7 PRI "HOW MANY PROBLEMS DO YOU WISH TO DO";
   8 INP P
   9 PRI
  10 PRI "HOW MANY DIGITS DO YOU WISH TO WORK WITH";
  12 INP N
  14 IF N<5 THEN 20
  16 PRI "THAT'S TOO MANY FOR MY TASTE.  WHY NOT TRY 4 OR"
  17 PRI "FEWER DIGITS, ALL RIGHT?  NOW THEN, HOW MANY DIGITS";
  18 GOT 12
  20 PRI
  22 LET W=0
  25 X=X+1
  27 Q=0
  30 A=INT(10↑N*RND(0))
  40 B=INT(10↑N*RND(0))
  50 PRINT
  60 PRI TAB(6-INT(LOG(A)/2.302585+1));A
  70 PRI TAB(5-INT(LOG(B)/2.302585+1));"+";B
  80 PRINT "  -----"
  90 PRINT "  ";
 100 INPUT G
 110 IF G=A+B THEN 140
 112 IF Q<2 THEN 122
 114 PRI "THAT'S THE THIRD TIME YOU MISSED THAT PROBLEM.
 115 PRI "THE CORRECT ANSWER IS "A+B"."
 117 PRI
 120 PRI "LET'S GO ON TO ANOTHER.
 121 GOT 25
 122 Q=Q+1
 123 IF Q>1 THEN 128
 125 W=W+1
 128 PRINT "WHAT?  TRY AGAIN."
 130 GO TO 50
 140 IF X=P THEN 155
 141 Y=Y+1
 142 IF Y<>1 THEN 145
 143 PRI "VERY GOOD!
 144 GOT 25
 145 IF Y<>2 THEN 148
 146 PRI "CORRECT.  HERE'S ANOTHER.
 147 GOT 25
 148 IF Y<>3 THEN 151
 149 PRI "YOU'RE A REAL MATH GIANT!
 150 GOT 25
 151 Y=0
 152 PRI "SUPER !!
 153 GOT 25
 155 PRINT
 160 PRINT "YOU GOT"P-W"CORRECT THE FIRST TIME"
 165 IF W<=3 THEN 180
 170 PRINT "BUT YOU MISSED"W
 175 STOP
 180 PRINT "GOOD WORK!"
 185 STOP
 999 END

STOP

READY
```

AREA: Mathematics NUMBER: NAME: CONVRG
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: The CONVRG series of programs will calculate:

1. e by an infinite series.
2. π by inscribed and circumscribe polygon.
3. π by infinite series (1 - 1/3 + 1/5 - 1/7 + 1/9...)

APPROACH: The above methods are commonly taught to show how and may be accurately calculated; however, it is difficult to carry out the calculations very far using pencil and paper alone.

The portion of the program to converge on e using the series

1 + 1/1 + 1/2 + 1/6 + 1/24 + 1/120 +...)

is as follows:

```
100 LET E=1
110 LET I=I+1
120 LET D=1
130 FOR J=1 TO I
140 LET D=D*J
150 NEXT J
160 LET E=E+1/D
170 PRINT E
180 GO TO 110
999 END

RUN

 2
 2.5
 2.666667
 2.708333
 2.716667
 2.718056
 2.718254
 2.718279
 2.718281
 2.718282
 2.718282
 2.718282
```

The portion of the program to converge on Pi by means of inscribed and circumscribed polygons is as follows:

```
 10 LET N=6
 20 LET N=2*N
 30 LET X=360/(N*57.29578)
 40 PRINT N*SIN(X)*COS(X)/2, N*TAN(X)/2
 50 GOTO 20
 99 END

READY

RUN

 2.598076        3.464102
 3               3.21539
 3.105829        3.15966
 3.132629        3.146086
 3.13935         3.142715
 3.141032        3.141873
 3.141453        3.141663
 3.141558        3.14161
 3.141584        3.141597
 3.141591        3.141594
 3.141592        3.141593
 3.141593        3.141593
 3.141593        3.141593

↑C
```

Convert degrees to radians.

Start with a 12-sided polygon

49,152-sided polygon

The third option, converging on Pi using an infinite series converges very slowly. Therefore, only every <u>500th</u> value is typed out.

```
300 LET S=1
310 LET I=1
320 LET Q=Q+1
330 LET P=P+S/I
340 LET I=I+2
350 LET S=-S
360 IF Q<499 THEN 320
370 LET Q=0
380 PRINT P*4
390 GO TO 320
999 END

RUN

 3.143597
 3.14059
 3.142261
 3.141091
 3.141994
 3.141259
 3.141879
 3.141342
 3.141816
 3.141392
 3.141775
 3.141426
 3.141748

↑C
```

7 seconds for each new value!

AREA: Mathematics　　**NUMBER:** 8-5　　**NAME:** DRINKR
SOURCE: Digital Equipment Corp.　　**LANGUAGE:** BASIC

DESCRIPTION: This program illustrates how the computer, used as an extended calculator, can solve the following problem:

35 persons per 1000 have high blood pressure. 80% of those with high blood pressure drink, and 60% without high blood pressure drink. Estimate the fraction of drinkers with high blood pressure.

APPROACH: This problem requires the solution of several simple equations. If we let H = the number of people with high blood pressure, then:

$$H = 35$$

And if H1 = the number of people with high blood pressure who drink, then:

$$H1 = .80 * H$$

Letting L1 - the number of people with low blood pressure who drink yields:

$$L1 = .60 * (1000 - H)$$

Now, we can solve for the number of drinkers, D:

$$D = H1 + L1$$

Finally, the percentage of drinkers with high blood pressure is:

$$X = H1 * 100 / D$$

The program below solves the problem in a jiffy:

```
READY

 5 PRINT "PROGRAM DRINKR"
 6 PRINT
10 LET H=35
20 LET H1=.8*H
30 LET L1=.6*(1000-H)
40 LET D=H1+L1
50 LET X=H*100/D
60 PRINT X;"% DRINKERS HAVE HIGH BLOOD PRESSURE."
70 PRINT H*100/1000;"% OF ALL PEOPLE HAVE HIGH BLOOD PRESSURE."
99 END

RUN

PROGRAM DRINKR

 5.766063 % DRINKERS HAVE HIGH BLOOD PRESSURE.
 3.5 % OF ALL PEOPLE HAVE HIGH BLOOD PRESSURE.


READY
```

EDUCATIONAL BENEFITS: This type of problem can be written directly in BASIC without going through the steps above. Recognizing this type of problem readily will save lots of pencil-pushing time.

AREA: Mathematics NUMBER: NAME: ROOTS
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: ROOT finds all the roots of a function (ANY FUNCTION!) between -20 and 20. The function may be quadratic, cubic, trigonometric or any combination.

APPROACH: The method used here involves evaluating the function at incremental values, finding places where the value of the function changes sign and then, by successive approximations, finding the zero point. This method is similar to the commonly taught "Newton's Method."

USAGE: Before typing RUN, enter the function to be evaluated as a DEF FNA(X) statement as line 100. Then type RUN. For example:

```
100 DEF FNA(X) = 2*X↑3+11*X↑2-31*X-180

100 DEF FNA(X) = SIN(X)-.5

100 DEF FNA(X) = X-4
```

EDUCATIONAL BENEFITS: The average student (especially in high school) does not have a thorough understanding of the very important concept of solving a function, much less an ability to do so for functions of any complexity. The computer lets them become very knowledgeable and confident in this area.

```
LIST


 100 DEF FNA(X)=2*X↑3 + 11*X↑2 - 31*X - 180
 110 LET Z1=-200
 120 FOR I=-19.9 TO 20
 130 IF SGN(FNA(I))=SGN(FNA(I+1)) THEN 300
 140 LET K=I
 150 LET J=I+1
 160 IF FNA(K)<FNA(J) THEN 200
 170 LET Z=K
 180 LET K=J
 190 LET J=Z
 200 LET Z=(K+J)/2
 210 IF FNA(Z)<0 THEN 240
 220 LET J=Z
 230 GO TO 250
 240 LET K=Z
 250 IF ABS(FNA(Z))>5.000000E-05 THEN 200
 260 LET Z=SGN(Z)*INT(ABS(Z)*10000+.5)/10000
 270 IF Z=Z1 THEN 300
 280 PRINT "F("Z")=0"
 290 LET Z1=Z
 300 NEXT I
 310 END

READY

100 DEF FNA(X)=X-4
RUN

F( 4 )=0


READY

100 DEF FNA(X)=SIN(X)-.5
RUN

F(-18.3259 )=0
F(-16.2315 )=0
F(-12.0428 )=0
F(-9.9483 )=0
F(-5.7596 )=0
F(-3.6651 )=0
F( .5236 )=0
F( 2.6179 )=0
F( 6.8068 )=0
F( 8.9011 )=0
F( 13.09 )=0
F( 15.1844 )=0
F( 19.3732 )=0


READY

100 DEF FNA(X)=2*X↑3 + 11*X↑2 - 31*X - 180
RUN

F(-5 )=0
F(-4.5 )=0
F( 4 )=0


READY
```

AREA: Mathematics NUMBER: 8-12 NAME: SETS-1
SOURCE: CAMP First Course, Scott, Foresman and Company
LANGUAGE: BASIC
DESCRIPTION: Program to determine the intersection of two sets of numbers.

USAGE: Two sets of numbers can be combined to yield a third set by the operation of intersection. The intersection of two sets A and B is the set that contains all elements that belong to both A and B. It does not contain any other elements. The intersection is usually written $A \cap B$.

For example, if $M = \{0,2,4,6\}$ and $K = \{1,2,3,4\}$, then $M \cap K = \{2,4\}$.

The computer can be instructed to find the intersection of two sets. A program for finding the intersection of set x = { 1,3,5,---19 } and y = { 2,5,8,---29 } is written below

```
 5 PRINT "PROGRAM SETS-1"
 6 PRINT
 7 PRINT "THE INTERSECTION OF SETS X AND Y IS:"
10 FOR X=1 TO 19 STEP 2
20 FOR Y=2 TO 29 STEP 3
30 IF X=Y THEN 70
40 NEXT Y
50 NEXT X
60 GO TO 99
70 PRINT X
80 GO TO 50
99 END

RUN

PROGRAM SETS-1

THE INTERSECTION OF SETS X AND Y IS:
 5
 11
 17


READY
```

Using the computer, complicated sets which would be tedious to do by hand may be examined by defining one or both sets in a data statement. In the following example, set y is the same as above, but set x is given in the DATA statement.

```
  5 PRINT "PROGRAM SETS-1"
  6 PRINT
  7 PRINT "THE INTERSECTION OF SETS X AND Y IS:"
 10 READ X
 20 FOR Y=2 TO 29 STEP 3
 30 IF X=Y THEN 70
 40 NEXT Y
 50 GO TO 10
 70 PRINT X
 80 GO TO 10
 90 DATA 2,3,8,9,14,15,20,21,26,27
 99 END

READY


RUN

PROGRAM SETS-1

THE INTERSECTION OF SETS X AND Y IS:
 2
 8
 14
 20
 26

OUT OF DATA IN LINE 10


READY
```

EDUCATIONAL BENEFITS: The student is able to see that if there is a numerical pattern in the sets which intersect, there is also a pattern in the resultant intersecting set. In the first example above, for instance, set x steps by 2 and set y steps by 3, hence the intersecting set steps by 2 x 3 = 6. More complicated sets can be examined by computer than can easily be done by hand.

AREA: Mathematics NUMBER: 8-13 NAME: SIMUL
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: The SIMUL program illustrates one way in which the computer can be used to solve relatively complex simultaneous equations.

USAGE: The computer can be used to solve simultaneous equations by trial and error far faster than we humans can. For example, let's solve for x and y in the following equations:

$$2^x = \frac{16y}{3} \quad \text{and} \quad 3^x = 27y$$

The program, which tries values of x and y between 0 and 100 until it reaches a solution or runs out of values is as follows:

```
 5 PRINT "PROGRAM SIMUL"
 6 PRINT "SOLUTION TO TWO SIMULTANEOUS EQUATIONS"
 7 PRINT
10 FOR X=1 TO 100
20 FOR Y=1 TO 100
30 IF 2↑X<>16*Y/3 THEN 50
40 IF 3↑X<>27*Y THEN 50
45 PRINT "X =";X,"Y =";Y
48 GO TO 99
50 NEXT Y
60 NEXT X
70 PRINT "NO INTEGER SOLUTION"
99 END

READY

RUN

PROGRAM SIMUL
SOLUTION TO TWO SIMULTANEOUS EQUATIONS

X = 4          Y = 3


READY
```

Let's try the same problem, but change Equation 2 slightly.

```
10 FOR X=1 TO 10
20 FOR Y=1 TO 10
40 IF 3↑X<>28*Y THEN 50

RUN

PROGRAM SIMUL
SOLUTION TO TWO SIMULTANEOUS EQUATIONS

NO INTEGER SOLUTION


READY
```

Oh, Oh. What went wrong?

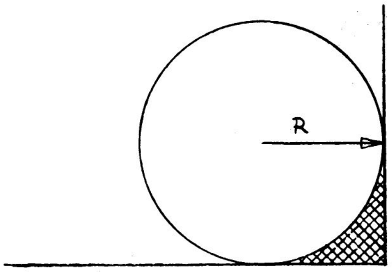
EDUCATIONAL BENEFITS: The student can see that trial and error, at least incrementing by whole numbers, does not always yield a solution, even trying 10,000 combinations. There must be another, better way.

Hint: Try combining the two equations and getting a solution for x using program ROOT. Then y can be easily solved for.

AREA: Geometry **NUMBER:** 8-16 **NAME:** Area-1

SOURCE: Computer Methods in Mathematics **LANGUAGE:** BASIC

DESCRIPTION: The problem is to solve for the shaded area of the figure below for any value of the radius, R.



APPROACH: We start by remembering that the area of a circle and square are calculated as follows:

$$A_{circle} = \pi * R^2$$

$$A_{square} = SIDE^2 \quad or \quad (2 * R)^2$$

The difference in area between a square and a circle inscribed within its borders is:

$$\Delta A = A_{square} - A_{circle}$$

and the area of one corner is:

$$A_{corner} = \Delta A/4$$

Now, let's write the program to perform this calculation for any input value of R.

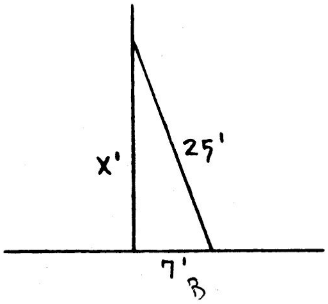
EDUCATIONAL BENEFITS: By trying different values of R, the student can determine relationships in areas as a function of the components. Let's try several values of R and see what happens.

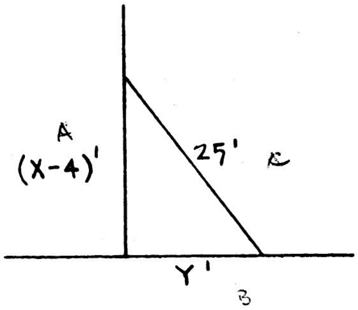
```
 5 PRINT "PROGRAM AREA-1"
 6 PRINT
 7 PRINT "WHAT IS THE RADIUS";
 8 INPUT R
 9 PRINT
10 LET P=3.14159
20 LET A1=P*R↑2
30 LET A2=(2*R)↑2
40 LET D=(A2-A1)/4
50 PRINT "AREA OF ENCLOSED CORNER IS";D
99 END

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 1

AREA OF ENCLOSED CORNER IS .2146025


READY

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 10

AREA OF ENCLOSED CORNER IS 21.46025


READY

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 100

AREA OF ENCLOSED CORNER IS 2146.025


READY

RUN

PROGRAM AREA-1

WHAT IS THE RADIUS? 2.158652

AREA OF ENCLOSED CORNER IS 1


READY
```

AREA: Geometry NUMBER: 8-18 NAME: LADDER
SOURCE: Digital Equipment Corporation LANGUAGE: BASIC
DESCRIPTION: The ladder program shows how the computer can be used to calculate the solution to the following word problem:

A ladder 25 feet long is placed so that its foot is 7 feet from the base of a building. When the top of the ladder slipped 4 feet down the side of the building, how far did the foot of the ladder slip?

USAGE: The diagrams below show the two ladder positions.





By the Pythagorean theorem we know that $a^2 + b^2 = c^2$, hence, the equations needed to solve the above problem are:

$$x = \sqrt{25^2 - 7^2}$$

$$y = \sqrt{25^2 - (x-4)^2}$$

and the amount of slippage of the base is:

$$z = y - 7$$

The program to do the problem is as follows:

```
READY

 5 PRINT "PROGRAM LADDER"
 6 PRINT
10 LET X=SQR(25*25-7*7)
20 LET Y=SQR(25*25-(X-4)*(X-4))
30 LET Z=Y-7
40 PRINT "LADDER BASE SLIPPED";Z;"FEET."
99 END

RUN

PROGRAM LADDER

LADDER BASE SLIPPED 8 FEET.


READY
```

EDUCATIONAL BENEFITS: While the arithmetic in the problem above is not particularly "messy", it still is no great joy to solve by hand. However, the computer would be equally happy to do the problem if the ladder is 27.83 feet long and it was 7.62 feet from the wall originally. Would you?

```
10 LET X=SQR(27.83↑2-7.62↑2)
20 LET Y=SQR(27.83↑2-(X-4)↑2)
30 LET Z=Y-7.62

RUN

PROGRAM LADDER

LADDER BASE SLIPPED 8.386132 FEET.


READY
```

AREA: Statistics/Games NUMBER: NAME: GUESS
SOURCE: Walter Koetke, Lexington High School LANGUAGE: BASIC

DESCRIPTION: The technique of binary search has a number of mathematical and programming applications. In program GUESS, the computer chooses a random integer between 0 and 100 and the student must try to guess what it is in as few tries as possible.

Note that the program does not reveal the technique of binary search, but merely alludes to the fact that no more than 7 guesses are necessary. Most students "discover" the idean of binary search after only a few runs of the program.

```
10 PRINT "I HAVE CHOSEN AN INTEGER 0 THROUGH 100.  TRY TO"
15 PRINT "GUESS MY NUMBER IN AS FEW TRIES AS POSSIBLE."
16 PRINT
20 LET C=0
22 RANDOMIZE
25 LET N=INT(RND(0)*100)
30 LET C=C+1
35 PRINT "YOUR GUESS IS";
40 INPUT G
45 IF N=G THEN 70
50 IF G>N THEN 60
55 PRINT "TOO LOW"
56 GO TO 30
60 PRINT "TOO HIGH"
65 GO TO 30
70 PRINT "CORRECT IN"C"GUESSES."
75 IF C>3 THEN 90
80 PRINT "YOU WERE LUCKY!"
85 STOP
90 IF C>7 THEN 100
95 PRINT "GOOD JOB."
98 STOP
100 PRINT "BUT YOU SHOULDN'T NEED MORE THAN 7 GUESSES."
105 END
```

```
READY

RUN

I HAVE CHOSEN AN INTEGER 0 THROUGH 100.  TRY TO
GUESS MY NUMBER IN AS FEW TRIES AS POSSIBLE.

YOUR GUESS IS? 50
TOO HIGH
YOUR GUESS IS? 25
TOO LOW
YOUR GUESS IS? 37
CORRECT IN 3 GUESSES.
YOU WERE LUCKY!


READY

RUN

I HAVE CHOSEN AN INTEGER 0 THROUGH 100.  TRY TO
GUESS MY NUMBER IN AS FEW TRIES AS POSSIBLE.

YOUR GUESS IS? 40
TOO LOW
YOUR GUESS IS? 80
TOO HIGH
YOUR GUESS IS? 68
TOO HIGH
YOUR GUESS IS? 66
TOO HIGH
YOUR GUESS IS? 45
TOO HIGH
YOUR GUESS IS? 35
TOO LOW
YOUR GUESS IS? 41
TOO LOW
YOUR GUESS IS? 43
TOO LOW
YOUR GUESS IS? 44
CORRECT IN 9 GUESSES.
BUT YOU SHOULDN'T NEED MORE THAN 7 GUESSES.


READY
```

EXTENSIONS: An excellent student assignment is writing a program which reverses the role of user and computer in Program GUESS. The computer should be programmed to guess a number the user has determined. After each guess, the user inputs 1, 2 or 3 for LOW, HIGH or CORRECT and the program continues until the correct number is found.

The program should guess any number between 0 and 100 in 7 guesses provided all the user clues are consistent. Writing the steps necessary to check the consistency of clues can be part of an assignment for better students.

AREA: Games NUMBER: NAME: SLOTS
SOURCE: Anonomous LANGUAGE: BASIC

DESCRIPTION: This program is a simulation of a slot machine, or one-arm bandit, of the type popular at Las Vegas, Monte Carlo and other gambling spas.

It is not a perfect simulation since three bars or three $ are frequently, at the real casinos, a big ($5 or $10) jackpot. However, the operation of the slot machine as simulated by this program is probably more honest than most existing real machines. Calculate the average number of "pulls" needed to lose $20.00. What is the probability of winning $20.00?

The program is on the reverse. The instructions and two "pulls" are shown below.

```
READY

RUN
DO YOU WISH INSTRUCTIONS 1-YES, 0-NO? 1
THIS IS A SIMULATION OF A SLOT MACHINE USING A COMPUTER
EACH TIME YOU 'PULL' I WILL ASK YOU IF YOU WISH TO PLAY AGAIN
IF YOU DO SIMPLY INPUT A'1' FOLLOWED BY A RETURN,
OTHERWISE INPUT A  '0' FOLLOWED BY A RETURN.
NOW WE ARE READY TO PLAY


          LEMON    LEMON    $
YOU HAVE LOST 1 DOLLAR -- TOTAL = $-1
                    DO YOU WISH TO PULL AGAIN? 1


          $        BELL    APPLE
YOU HAVE LOST 1 DOLLAR -- TOTAL = $-2
                    DO YOU WISH TO PULL AGAIN? 0
IT'S BEEN NICE OPERATING FOR YOU COME BACK SOON!
```

```
READY

TAPE

  1 RANDOMIZE
  2 DIM D(3)
  5 PRINT"DO YOU WISH INSTRUCTIONS 1-YES, 0-NO";
  6 INPUT J
  7 IF J=0 THEN 13
  8 PRINT"THIS IS A SIMULATION OF A SLOT MACHINE USING A COMPUTER "
  9 PRINT"EACH TIME YOU 'PULL' I WILL ASK YOU IF YOU WISH TO PLAY AGAIN"

 10 PRINT"IF YOU DO SIMPLY INPUT A'1' FOLLOWED BY A RETURN,"
 11 PRINT"OTHERWISE INPUT A  '0' FOLLOWED BY A RETURN."
 12 PRINT"NOW WE ARE READY TO PLAY "
 13 PRINT
 14 PRINT
 15 PRINT TAB (9)" ";
100 FOR B1=1 TO 3
110 LET D(B1)=INT(RND(0)*6)+1
120 NEXT B1
130 FOR G1=1 TO 3
140 IF D(G1)=1 THEN 390
150 IF D(G1)=2 THE N 410
160 IF D(G1)=3 THEN 430
170 IF D(G1)=4 THEN 450
180 IF D(G1)=5 THEN 470
190 IF D(G1)=6 THEN 490
385 GOTO 999
390 PRINT"BELL     ";
400 GOTO 500
410 PRINT"BAR        ";
420 GOTO 500
430 PRINT "CHERRY   ";
440 GOTO 500
450 PRINT "APPLE    ";
460 GOTO 500
470 PRINT "LEMON    ";
480 GOTO 500
490 PRINT "$        ";
500 NEXT G1
510 IF D(1)<>D(2) THEN 520
511 IF D(2)=D(3) THEN 600
520 PRINT
530 IF D(1)=D(3) THEN 550
531 LET B=B-1
532 PRINT "YOU HAVE LOST 1 DOLLAR -- TOTAL = $"B
533 GOTO 800
550 LET B=B+.50
560 PRINT "YOU HAVE WON 50 CENTS -- TOTAL = $"B
570 GOTO 800
600 LET B=B+1
610 PRINT"YOU HAVE WON 1 DOLLAR -- TOTAL $"B
620 GOTO 800
800 PRINT TAB(20)"DO YOU WISH TO PULL AGAIN";
801 INPUT J
802 IF J=1 THEN 13
803 PRINT"IT'S BEEN NICE OPERATING FOR YOU COME BACK SOON!"
999 END

READY
```

AREA: Plotting NUMBER: NAME: DIAMON
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program prints an N by N matrix of diamond shapes, each one being R (odd number input) characters wide.

```
3 PRINT "FOR A PRETTY DIAMOND PATTERN, "
4 PRINT "TYPE IN AN ODD NUMBER BETWEEN 4 AND 32."
5 INPUT R
6 LET Q=INT(60/R)
8 FOR L=1 TO Q
11 LET X=1
12 LET Y=R
13 LET Z=2
20 FOR N=X TO Y STEP Z
25 PRINT TAB((R-N)/2);
28 FOR M=1 TO Q
29 LET C=1
30 FOR A= 1 TO N
32 IF C=1 THEN 40
33 IF C=2 THEN 42
34 IF C=3 THEN 44
35 PRINT "!";
37 GOTO 50
40 PRINT "D";
41 GOTO 47
42 PRINT "E";
43 GO TO 47
44 PRINT "C";
47 LET C=C+1
50 NEXT A
53 IF M=Q THEN 60
55 PRINT TAB(R*M+(R-N)/2);
56 NEXT M
60 PRINT
70 NEXT N
83 IF X<>1 THEN 95
85 LET X=R-2
86 LET Y=1
87 LET Z=-2
90 GOTO 20
95 NEXT L
99 END
```

```
FOR A PRETTY DIAMOND PATTERN,
TYPE IN AN ODD NUMBER BETWEEN 4 AND 32.
? 15
       D              D              D              D
      DEC            DEC            DEC            DEC
     DEC!!          DEC!!          DEC!!          DEC!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
 DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!
DEC!!!!!!!!!!!!DEC!!!!!!!!!!!!DEC!!!!!!!!!!!!DEC!!!!!!!!!!!!
 DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!
  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
     DEC!!          DEC!!          DEC!!          DEC!!
      DEC            DEC            DEC            DEC
       D              D              D              D
       D              D              D              D
      DEC            DEC            DEC            DEC
     DEC!!          DEC!!          DEC!!          DEC!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
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  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
     DEC!!          DEC!!          DEC!!          DEC!!
      DEC            DEC            DEC            DEC
       D              D              D              D
       D              D              D              D
      DEC            DEC            DEC            DEC
     DEC!!          DEC!!          DEC!!          DEC!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
 DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!
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  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
     DEC!!          DEC!!          DEC!!          DEC!!
      DEC            DEC            DEC            DEC
       D              D              D              D
       D              D              D              D
      DEC            DEC            DEC            DEC
     DEC!!          DEC!!          DEC!!          DEC!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
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DEC!!!!!!!!!!!!DEC!!!!!!!!!!!!DEC!!!!!!!!!!!!DEC!!!!!!!!!!!!
 DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!  DEC!!!!!!!!!!
  DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!    DEC!!!!!!!!
   DEC!!!!!!      DEC!!!!!!      DEC!!!!!!      DEC!!!!!!
    DEC!!!!        DEC!!!!        DEC!!!!        DEC!!!!
     DEC!!          DEC!!          DEC!!          DEC!!
      DEC            DEC            DEC            DEC
       D              D              D              D
```

AREA: Plotting NUMBER: NAME: PLOTFN
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: This program accepts any input function, f(x), at the time of program execution and plots that function from X_{min} to X_{max} in steps of S. The program also inserts the y axis, if it is crossed. Functions which can be plotted range from very simple to rather complex. All of the following are plottable functions:

Function	X Limits		Increment
f(x) = 2 * x	-15	+15	1
f(x) = 30*SIN(x)	-5	+5	.25
f(x) = x-x↑2	-5	+6	.5
f(x) = 30*SIN(.5*x)*EXP(-.2*ABS(x))	0	+15	.25

The program is on the reverse. A sample plot is shown below:

```
WHAT ARE THE INITIAL AND FINAL VALUES OF X, AND THE
INCREMENT SIZE? -5,6,1


                                 X =-5
                                   .                             *
                                   .                   *
                                   .           *
                                   .     *
                                   . *
-Y . . . . . . . . . . . . . . . . .*. . . . . . . . . . . . . . . . +Y
    -30       -20       -10        0        +10       +20       +30
                                   . *
                                   .     *
                                   .           *
                                   .                   *
                                   .                             *
                                 X = 6
```

```
110 PRINT "TO PLOT Y=F(X), THE USER MUST TYPE:"
120 PRINT
130 PRINT "100 GOTO 200"
140 PRINT "200 DEF FNA(X)=(THE EXPRESSION FOR F(X))"
150 PRINT "RUN"
160 PRINT
190 STOP
200 DEF FNA(X)=2*X
210 PRINT
220 PRINT "WHAT ARE THE INITIAL AND FINAL VALUES OF X, AND THE"
 230 PRINT "INCREMENT SIZE";
240 INPUT X1, X2, S
250 PRINT
260 PRINT
270 PRINT TAB(33); "X ="; X1
280 FOR X=X1 TO X2 STEP S
290 IF ABS(X)<.000001 THEN 362
340 LET Y = FNA(X) + 35
350 IF Y>35 THEN 380
360 PRINT TAB(Y);"*";TAB(35);"."
361 GO TO 390
362 PRINT "-Y . . . . . . . . . . . . . . . . . . . . . . . . .  .";
363 PRINT " . . . . . . . +Y";TAB(FNA(X)+35);"*"
364 PRINT TAB(4);"-30";TAB(14);"-20";TAB(24);"-10";TAB(35);"0";
 365 PRINT TAB(44);"+10";TAB(54);"+20";TAB(64);"+30";
370 GOTO 390
380 PRINT TAB(35);".";TAB(Y);"*"
390 NEXT X
400 PRINT TAB(33);"X =";X2
410 PRINT
440 END

READY

RUN

TO PLOT Y=F(X), THE USER MUST TYPE:

100 GOTO 200
200 DEF FNA(X)=(THE EXPRESSION FOR F(X))
RUN



READY

100 GOTO 200
200 DEF FNA(X)=X↑2-X
RUN


WHAT ARE THE INITIAL AND FINAL VALUES OF X, AND THE
INCREMENT SIZE? -5,6,1
```

(See Plot on Front of Page)

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